The Vertical Motion of Matter in Quiescent Prominences

Jun Kubota
Kwasan and Hida Observatories, University of Kyoto, Kyoto 607

In order to understand the problem of mass balance in quiescent prominence and its evolution, it is important to know the velocity of vertical motion of matter. We have been securred spectroscopic observations of dark filaments and studied the vertical motion of matter by measuring the wavelength shift in the CaII K line at various portions in the dark filament appeared near the disk center.

Observations were made at the Kwasan Observatory with the horizontal solar telescope and the spectrograph and also at the Hida Observatory with the domeless telescope and the horizontal spectrograph. Spectra of the CaII K line were taken with a mean dispersion of 0.3Å/mm, by setting the entrance slit of spectrograph on the various portion of the image of the filament at the prime focus of the telescope. Microdensitometric tracings of the spectra were made along the direction of dispersion within a range of ±10Å from the K line center, and then, the profile of the K line and the relation between measured distance from standard line(x) and the wavelength were obtained.

The theoretical profile of the CaII K line in a homogeneous cloud model can be expressed by assuming constant source function throughout the cloud; $I_\lambda = I_b \exp(-\tau_\lambda) + S[1 - \exp(-\tau_\lambda)]$, where $\tau_\lambda = \tau_0 \exp[-\{(\Delta\lambda - \lambda v/c)/\Delta\lambda_D\}^2]$ and I_b is the background intensity from underlying chromosphere, τ_0, the optical thickness of the cloud at the K line center, v, the velocity of the cloud against the photosphere along the line of sight. The contrast function is defined as $C(\lambda) = (I_b - I_\lambda)/I_b$. We estimated the profiles of the CaII K line and the contrast function in the model cloud in a range of τ_0 from 1 to 5 and of v from 0.5 to 10km/s. Here I_b is taken from the White and Suemoto's measurements(1968). For $v<2$km/s and

$\tau_0<5$, however, our estimated contrast function does not show distinct maximum. Without knowing real τ_0 in the dark filament, therefore, the estimation of the velocity by the contrast function method may lead to noticeable errors. Our observed profiles of the CaII K line in the dark filament are compared with the estimated ones for various v and τ_0 combinations.

When $\tau_0<2$, the intensity of the CaII K line in the dark filament is much affected by the background radiation. Moreover, if the filament is composed of fine threads of matter, the background radiation from underlying chromosphere would partly pass through the filament and change the intensity of the K line we observed. The minimum intensity in the profile of the K line, I_M , is nearly equal to the source function in the filament, when τ_0 is sufficiently large and I_M is scarcely affected by the background radiation. The excitation temperature of the CaII K line in the quiescent prominence is about 3800K in general. Thus we used the observed profile of K line in which $I_M \simeq S = B(3800)$ is fulfilled for this study. The shift of the CaII K line in the dark filament against the photospheric and chromospheric lines is carefully measured by interpolation with the x vs. λ curve. Then the vertical velocity of matter can be obtained within a range of error of 0.5km/s.

Figure 1 gives histograms of vertical velocity measured in three dark filaments(A: September 3, 1972, B: August 22, 1979 and C: August 11, 1980). The average values of velocities in each filaments are 0.8, 1.4 and -0.2km/s respectively(Minus sign designates upward motion). The downward motion is predominant in A and B filaments, while both downward and upward motions are detected in C filament. The difference of average velocities in these filaments may be due to the evolutional effect; The C filament was young, while others(A and B) were in the middle and old stages in their evolution(Fraunhofer Solar Map and Solar Geophysical Data).

The large velocity(v>4km/s) is detected in some portions of every filaments. Maltby(1976) also obtained large velocity in several portions of filament from his monochromatic observations in Hα light. However, we still can not clarify the relation between the existence of such large velocity and the spatial structure of the dark filament; such as foot, head etc.

The time required for the exchange of total matter in the filament with newly supplied one from surrounding corona is estimated to be 595 minutes(10 hours), when the height of quiescent prominences is 5 x 10^4km and the downward velocity is 1.4km/s.

References

Maltby, P ; 1976, Solar Phys., 46, 149.
White, O. R., and Suemoto, Z.; 1968, Solar Phys., 3, 523.

Fig. 1

Histograms of vertival velocity in three dark filaments.
A: September 3, 1972, B: August 22, 1979, C: August 11, 1980.